NCC8-65

To Perform Fundamental Research and Applied Technology in the Areas of Space Physics and Astrophysics Via Utilization of the Available Flight Experiments and Development of Future Programs

(Annual Report)
Period of Performance: February 15, 1995 - February 14, 1996

Submitted by:

The University of Alabama in Huntsville
on behalf of
The Institute for Space Physics, Astrophysics and Education (ISPAE)*

* A jointly operated institute; The University of Alabama in Huntsville (CSPAR) and The Universities Space Research Association

The University of Alabama in Huntsville (UAH) was awarded the grant NCC8-65 entitled "Perform Fundamental Research and Applied Technology in the Areas of Space Physics and Astrophysics via Utilization of the Available Flight Experiments and Development of Future Programs" effective February 15, 1995 for three years. Funding was obligated incrementally for a period ending February 14, 1997. As of December 1, 1996, UAH has received incremental funding in the amount of $5,038,775.85. The initial proposal was submitted by UAH under the aegis of the Institute for Space Physics, Astrophysics and Education (ISPAE) which consists of UAH and USRA. The proposal included subcontracting with USRA. Dr. S. T. Wu, the Distinguished Professor of the Department of Mechanical and Aerospace Engineering, Director of the Center for Space Plasma and Aeronomic Research serves as the Principal Investigator/Director for ISPAE. Dr. Chryssa Kouveliotou, Associate Research Scientist and On-Site Astronomy Program Coordinator for USRA serves as the Co-Principal Investigator/Deputy Director for ISPAE. Other faculty members at the UAH/ISPAE and USRA collaborate with scientists at the NASA/Marshall Space Flight Center/Physics and Astronomy Division (NASA/MSFC/PAD) to perform space physics and astrophysics research. In the following, we discuss the UAH portion of the activities. The USRA activities are included in a separate report which was submitted as a sub-contract report (Appendix I).

The ISPAE researchers are grouped into six disciplines which are X-Ray Astronomy, Gamma Ray Astrophysics, Cosmic Ray Astrophysics, Gravitational Physics, Solar Physics, Space Plasma Physics. All disciplines are participants of the educational outreach program. The activities for each discipline are described in the following:

1. X-Ray Astronomy

Most of the ISPAE members of this discipline are with USRA. See the USRA Activity Report SUB96-077 (Appendix I) for specific activities.

UAH has received support only for a Physics Department graduate student (Mr. Kim Ong) working under the direction of Professor Z. E. Musielak at the Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Mechanical and Aerospace Engineering and Dr. M. Weisskopf (MSFC). During the this period of performance they constructed first purely theoretical, self-consistent and time-dependent solar wind models using a modified version of the ZEUS code. The models are radially symmetric and the initial atmosphere is magnetized and expanding. The outflow is described by standard Parker's wind solution and the effects of Alfven waves on the outflow are investigated by solving the full set of ideal and nonlinear MHD equations. In contrast to previous studies, no assumptions regarding wave linearity, wave damping and wave-flow interaction are made. The constructed models naturally account for the backreaction of the wind on the waves and for the nonlinear interaction between different types of MHD waves. For a perturbed wave amplitude about 50-100 km/s, results clearly demonstrate that momentum deposition by Alfven waves in the solar wind is sufficient to explain the origin of the fast stream in solar coronal holes.

2. Gamma Ray Astrophysics

The members of this discipline are almost equally divided between UAH and USRA. UAH employed thirteen (13) research professors, research associates, research analysts, and graduate research assistants in collaboration with the NASA/MSFC Physics and Astronomy Division:

Dr. W. Paciesas, Research Professor
Dr. J. van Paradijs, Eminent Scholar
Dr. J. Brainerd, Senior Research Associate
Dr. M. Brigggs, Senior Research Associate
Ms. K. Deal-Giblin, Research Analyst III
Dr. Stefan Dieters, Research Associate
Dr. Richard Kipplin, Research Associate
Mr. V. Mizzell, Research Analyst III
Dr. G. Pendleton, Assistant Research Professor
Dr. R. Preece, Senior Research Associate
Dr. T. Koshut, Dept. of Physics Graduate Research Assistant
Mr. R. Mallozzi, Dept. of Physics Graduate Research Assistant
Ms. G. Richardson, Dept. of Physics Graduate Research Assistant
Mr. S. Patel, Dept. of Physics Graduate Research Assistant
Mr. M. Stollberg, Dept. of Physics Graduate Research Assistant
Mr. P. Woods, Dept. of Physics Graduate Research Assistant
Mr. S. Phengchamnan, Dept. of Physics Graduate Research Assistant

Prof. William Paciesas continued his administrative duties as BATSE co-investigator, supervisor of the UAH/BATSE gamma-ray group, and principal investigator for the BATSE gamma-ray burst spectroscopy key project. He provided guidance to several UAH graduate students. He also was responsible for operational oversight of the BATSE spectroscopy detectors. He continued to lead the effort to extend the BATSE capabilities for all-sky monitoring to lower energies by applying the Earth occultation technique to spectroscopy detector data. He also continued to participate actively in the BATSE burst analysis and occultation source analysis teams, particularly in studies of state transitions and long-term variability of Cyg X-1, transient outbursts of the superluminal jet sources GRS 1915+105 and GRO J1655-40, time-resolved spectroscopy of gamma-ray bursts, and searches for spectral features in bursts. He was involved in various collaborations with outside investigators to analyze BATSE data in combination with data from other instruments on RXTE and SAX, focusing primarily on observations of galactic black hole candidates but also including other sources such as low-mass X-ray binaries and active galactic nuclei.

Prof. Jan van Paradijs collaborated with members of the BATSE burst, occultation, pulsar, and periodic variability teams in studies of various sources using BATSE data, including the bursting pulsar GRO J1744-28, Cyg X-1, GRO J1719-24, A 0535+26, and the soft gamma-ray repeaters. He was co-organizer of the NATO workshop "The Many Faces of Neutron Stars" (Lipari, Italy, September 1996).

Dr. Michael Briggs continued the exhaustive automatic search for low-energy spectral features in gamma-ray bursts. He has found several candidate features and is now studying these in more detail in collaboration with other members of the BATSE team. He co-edited the proceedings of the Third Huntsville Gamma-Ray Burst Symposium, which will published by the AIP press in 1997. Dr. Briggs was also actively involved in studies of the bursting pulsar GRO J1744-28, concentrating specifically on analysis of the burst spectra and calculation of their influences. He continued to coordinate the collaborative effort with the Russian Space Research Institute to study average temporal/spectral properties of gamma-ray bursts. He also continued to maintain the MFIT software for spectral deconvolution.

Dr. Jim Brainerd continued his work on fitting his Compton attenuation model to time-integrated burst spectra. A paper describing these results was submitted to ApJ. He is now extending this study to time-resolved burst spectra to further test the model. He also compared the effectiveness of the two-point correlation function versus the nearest neighbor analysis as a test for burst repetition. A paper describing this is in press in ApJ. He began an investigation of the effects of a burst intrinsic luminosity distribution on the flux-intensity distribution, redshift and time dilation expected in cosmological burst scenarios. Dr. Brainerd continued to serve as manager of the BATSE World Wide Web pages and coordinator of a theoretical astrophysics seminar series for the BATSE team.

Dr. Rob Preece completed a project to examine the low-energy behavior of burst spectra. He found that a substantial fraction of bursts have excess emission above that expected from an extrapolation of the high-energy spectrum. The results were published in ApJ. He also has in progress a project to examine in detail the behavior of burst spectra at high energies. A draft manuscript has been circulated to co-authors for comments. Dr. Preece has also been involved extensively in BATSE detector calibration efforts, particularly in evaluation and implementation of the 191 keV background line as an alternative to the 511 keV line for energy calibration, and improvement of the low-energy calibration of the large area detectors. He also continued maintenance of BFITS and WINGSPAN software and supervised improvements to the COR_HER and COR_SHER routines. He functioned as main point of contact for various collaborations with outside investigators at Rice U., NASA/GSFC, and Washington U. He is serving on the local organizing committee for the Fourth Huntsville Gamma Ray Burst Symposium.

Dr. Geoff Pendleton completed a project to improve the BATSE burst location software. The resulting systematic errors are now estimated to be less than two degrees. The improved locations were included in the BATSE 3B catalog, which was published in ApJ Supplements. Dr. Pendleton continued his major research project to perform low-resolution spectral analysis of the entire catalog of BATSE bursts. He found that the bursts with softest high-energy spectra appear to be nearly homogeneous in their spatial distribution. However, time-resolved spectral analysis of harder bursts showed a population of soft peaks within them which have similar characteristics to the soft bursts. He interpreted this as evidence for a single source population with two types of burst emission rather than two separate population of burst sources. A paper describing this has been submitted to ApJ. Dr. Pendleton is also supervising preparation of a BATSE burst spectroscopy catalog.

Dr. Marc Kippen was added to the BATSE team in April 1996. He is involved in a project to analyze the small-scale angular distribution of gamma-ray bursts using combined BATSE/Ulysses locations. This is expected to allow more sensitive searches for burst repetition and/or spatial clustering.

Dr. Stefan Dieters was added to the BATSE team in May 1996. He has divided his time between BATSE and RXTE-related activities. His BATSE efforts have mainly been directed toward various pulsar analysis projects. Recently he has become involved extensively in studies of the renewed activity from the soft gamma repeater SGR 1806-20, which is a joint project combining BATSE and RXTE data.

Dr. Bob Mallozzi received his PhD from UAH in May 1996 and was added to the BATSE team as a Research Associate in June 1996. His dissertation "Cosmological Effects on Gamma Ray Bursts Observed with BATSE" was completed under the supervision of Prof. Paciesas. He has subsequently completed a related investigation studying gamma-ray burst redshift constraints from BATSE data which has been published in ApJ. He was heavily involved in development of a widget-based interface for WINGSPAN and porting this code to UNIX systems. He also designed a World Wide Web interface to the BATSE burst data base to facilitate public access. He continued to participate in the ongoing study of transient gamma-ray flashes detected by BATSE.

Mr. Mark Stollberg, a UAH graduate student, continued writing his PhD dissertation, which will provide constraints on the orbital parameters of the Be X-ray binary EXO 2030+375, using BATSE data. He has produced a draft of a paper which will be submitted to Ap J.

Mr. Tim Giblin, a UAH graduate student, continued work on his PhD dissertation, which focuses on analysis of short-term, mostly aperiodic, variability of gamma-ray bursts using power spectral analysis.

Ms. Kim Deal continued her regular activities in BATSE mission operations, including daily data reduction and archival operations as well as quick-look burst trigger science operations. She had primary responsibility for preparation of occultation source histories for delivery to the CGRO Science Support Center. She also participated in analysis of data from the bursting pulsar GRO J1744-28.

UAH graduate students Peter Woods, Georgia Richardson, Surasak Phengchamnan, and Sandip Patel all contributed to quick-look burst trigger science operations and were involved in various aspects of BATSE data archival and data analyses. Woods contributed substantially to analysis of GRO J1744-28. Woods and Phengchamnan have been trained in operation of the software for determining burst fluxes and fluences in preparation for production of the next BATSE burst catalog installment. Phenchamnan assisted Briggs in a study of systematic errors in burst spectral analysis.

See the USRA Activity Report SUB96-077 (Appendix I) for Gamma Ray USRA activities.

3. Cosmic Ray

Elemental Abundance of High Energy Cosmic Rays by Antarctic Balloon Flight Experiments

The UAH JACEE team in collaboration with the NASA/MSFC team has carried out a series of balloon flight experiments to explore the elemental composition of these high energy nuclei for the first time, directly measuring the primary charges and energies with emulsion chambers. We performed (1) detector designing, (2) emulsion materials production, (3) balloon flights, (4) post-flight processing, (6) photometry and scanning of events, and (6) cosmic ray event tracing in the detector.

At high energies above 100 TeV/n (~ 5 x 10^15 eV for Fe), a spectral break (- Knee -) has long been recognized by the Extensive Air Shower (EAS) observations. Interstellar and supernova shock acceleration mechanisms encounter a great theoretical difficulty at this very energy region. Experimental data were, however, limited to the indirect energy flow spectrum and the data on the elemental abundance were missing. The JACEE group's balloon flight experiments with emulsion chambers has landmarked the first direct measurements of cosmic rays at the critical high energy region.

Very high energy spectra of cosmic ray nuclei have been analyzed. From a total of 12 balloon flights, with an exposure factor of about 580 square-meter hour, the world's largest to date, the energy spectra of cosmic ray nuclei have been obtained in the energy range from several TeV to 1,000 TeV. The proton energy spectrum extending to several times 100 TeV showed a single-power law with some deficiency of statistics above 50 - 100 TeV. The helium spectrum is consistent with a single-power law in the energy range from 2 TeV/n to 200 TeV/n. Other nuclei up to Fe indicated harder spectral indices compared with those of protons and helium. The particle composition at around 500 TeV is 16 +- 5%: 29 +- 5%: 35 +- 5%: 9 +- 3%:11 +- 4%, for the abundance of p : He : C ~ O : Ne ~ S : Z > 17.

4. Gravitational Physics

The gravitational physics research effort was focused on computer simulation studies for Gravity Probe B (GP-B). The purpose of this research is to investigate disturbances and experiment system performance during the mission and their affect on the scientific measurements. The UAH gravitational physics team visited Stanford GP-B group in May 1996 to review the experiment simulation work done at Stanford University and discuss a joint approach for future simulation studies. The Stanford GP-B computer program was obtained and modified for simplified simulation studies with a PC. The results of this work was documented in a report. Work began on an advanced and expanded computer simulation of the experiment including science measurements and data reduction. This computer program will be used with a Sun Work Station to simulate and analyze the experiment during a one year mission.

An analytical study of error torques on the GP-B science gyroscope was completed and a report was prepared. A computer simulation study to investigate the errors caused by noise in the experiment readout (SQUID) system was started and will be completed early in 1997. A review of all experiment errors was carried out to identify the most critical error sources and to define further analytical investigations needed to assess the science measurement accuracy of the experiment. This effort was carried out in collaboration with NASA scientists. Corresponding studies will be started in 1997.

5. Solar Physics

The funded solar physics group (consisting only of UAH employees) are:

Dr. S. F. Nerney, Research Scientist
Dr. A. H. Wang, Research Associate
Dr. S. T. Wu. Distinguished Professor; Director, CSPAR; and Director, ISPAE
Dr. R. Chipman, Professor, Department of Physics

The solar physics group's ISPAE funded activities can be classified into two categories: (i) programmatic activities and (ii) research activities:

Programmatic Activities

We have performed tasks to define the mechanisms of solar variability program. One Working group meeting was held November 20, 21, 1996 at Huntsville, Alabama. ISPAE provided for actual travel reimbursement for ten of the science definition team. The meeting was to plan for possible implementation to further define and plan a prospective space physics research program focused on the physical origins and processes of the Sun's magnetic activity, which is the root cause and driver of the Earth's space environment. High-resolution space-based imaged observations of the currently Sun's surface and atmosphere are the centerpiece of the MSV Program. Japan participating in this mission and Germany is considering participation in the Solar-B part of the program. NASA Headquarters has requested that MSFC maintain active in this MSV program. Working group members of leading scientists of the US high-resolution solar research community meet to advise NASA on how the community can best participate in the international solar mission and how this participation would fit into and advance the overall MSV Program. Meetings are planned and carried out with the full participation of the MSFC MSV Project Scientists, thus most of the meetings are held in Huntsville, Alabama. The University of Alabama in Huntsville convenes and facilitates meetings of US solar scientist to review and update plans for NASA's Mechanisms of Solar Variability Program, with particular attention to the options for NASA participation in the next Japanese solar space mission. The University works closely with the MSFC working group chairman and project scientists.

Drs. Alan Gary (NASA/MSFC) and S. T. Wu co-chaired a workshop entitled "Workshop on measurements and analyses of the 3-D solar magnetic field" held at the Holiday Inn, held April 9 - 11, 1996. Each session started with invited presentation followed by contributed oral

presentations. The sessions ended with an open debate each day. Poster sessions paralleled the oral presentations. Fifty-eight scientist from around the world attended the workshop. The proceeding will be published as a special issue of Solar Physics in 1997.

Research Activities

In this period of time, our major achievement is to complete the development of a multi-dimensional global coronal hole and streamer model. This model includes volumetric heating and momentum addition. Four papers were published or submitted for publication; they are:

Inferences on Coronal Magnetic Fields from SOHO/UVCS Observations by G. Poletto, M. Romoli, S. T. Suess, A. H. Wang, S. T. Wu, *Solar Phys.*, 1996 (in press).

Volumetric heating in coronal streamers, by S. T. Suess, A.-H. Wang and S. T. Wu, *J. of Geophysical Res.*, 101, No. A9, 19,957-19,966, 1996.
The geometric spreading of coronal plumes and coronal holes, by S. T. Suess, G. Poletto, A. H. Wang, I. Cuseri, S. T. Wu, R. S. Steinolfson, *J. Geophysical Res.*, 1996 (submitted).

A global model of the corona with heat and momentum addition, by A. H. Wang, S. T. Wu, S. T. Suess, G. Poletto, *J. Geophysical Res.*, 1996 (submitted).

6. Space Plasma Physics

The funded members of this discipline are divided between UAH and USRA. UAH employed ten (10) professors, research professors and research associate, graduate and undergraduate research assistants during the period of performance.

Dr. J. Horwitz, Professor and Associate Director of CSPAR
Dr. R. H. Comfort, Research Professor and Assistant Director of CSPAR
Dr. G. Germany, Research Associate
Dr. M. Hirahara, Visiting Scholar/Research Associate
Mr. M. Adrian, Dept. of Physics Graduate Research Assistant
Ms. H. Elliott, Dept. of Physics Graduate Research Assistant
Ms. Y. Su, Dept. of Physics Graduate Research Assistant
Ms. K. Venturini, Dept. of Physics Graduate Research Assistant
Mr. S. Wolfe, Dept. of Physics Undergraduate Student Assistant
Dr. M.-C. Fok, USRA, Research Scientist

In work involving primarily Masa Hirahara and Jim Horwitz as well as several MSFC colleagues, analysis of TIDE and other data from the POLAR satellite, launched in February, 1997, has been conducted. The signatures of the upflowing ionospheric ions and the auroral forms are the main subject of this work. We demonstrated that the upflowing ion conic events which are often observed in the cusp region show some crucial features, including differences between O+ and H+ cone angles, to reveal the mechanisms energizing and supplying the ionospheric ions into the magnetosphere. The relation of the upflowing ion signatures with the

auroral activities is also intensively examined. We proposed that the electrostatic potential drop parallel to the magnetic field is a major cause of the upflowing ion beams and the auroral arcs associated with high-frequency electromagnetic plasma waves. Otherwise, the ion conics were well-correrated with relatively low-frequency waves, while the bright auroral emissions are at times observed outside the regions with the conic signatures. In these works, valuable data from the other instruments (e.g. electric field instrument and plasma wave instrument) on POLAR and ground magnetogram stations are being studied in addition to the data from the Thermal Ion Dynamics Experiment (TIDE) and the Ultraviolet Imager (UVI), which were developed in MSFC and UAH for the POLAR mission. Recently, also involving Yi-Jiun Su, we have also initiated a study of the polar wind in the context of photo-electrons and other electron properties observed in the polar cap magnetosphere. We will compare the TIDE results with the plasma and magnetic field data from the POLAR and WIND satellites to reveal the mechanism accelerating the ionospheric ions and statistical properties in detail.

Jim Horwitz and Masa Hirahara also participated in the International Space Science Institute October 1996 workshop and other activities associated with Sources and Losses of Magnetospheric Plasmas. Jim Horwitz participated with MSFC colleagues Dennis Gallagher and Tom Moore in the convening of the Huntsville 96 workshop on "Encounter between Global Models and Observations in the ISTP Era". Horwitz also initiated new projects associated with POLAR/TIDE in connection with the GEM meeting in June 1996.

In work led by Mei-Ching Fok in collaboration with MSFC colleagues, improvements have been made in the ring current model, which is a kinetic model solving the temporal variation of the ring current ion distributions in a 3-D spatial space. The model has been extended to include relativistic energy, realistic magnetic field and electric field models. The energetic neutral atoms emitted from the inner magnetosphere, as a result of ring current decay, is also simulated. This modeling work is directly relevant to the IMAGE (Imager for Magnetopause-to-Aurora Global Exploration) mission, which was selected as the first MIDEX mission. One of the scientific objectives of IMAGE is to image the ring current using the energetic neutral atoms.

In work led by Hugh Comfort and Heather Elliott, we have participated in the modeling of laboratory calibration data for the Thermal Ion Dynamics Experiment (TIDE), so that it can be used effectively in data reduction routines. We have also helped test software developed for analysis of TIDE data and aided in troubleshooting analysis techniques. We have prepared and presented analyzed TIDE data in scientific meetings. A primary initial focus is on the results of the moments calculations near apogee and perigee over the polar and auroral regions. We have also taken initial steps to present PSI (Plasma Source Instrument) data to meetings where this information would be of interest. Of particular interest is the stable spacecraft potential which the PSI is able to maintain and what is revealed in the TIDE observations when this is done at apogee. In ongoing analysis of DE1/RIMS data, we have worked with SSL scientists in continuing development and refinement of the thermal plasma empirical model for both low latitude and high latitude regions.

In work led by Catherine Venturini, we have also worked with SSL scientists to assemble equipment for a laboratory experiment to examine the 'microphysics' of dusty plasmas. This assembly is almost completed and preliminary testing is being carried out.

Work led by M. Adrian in cooperation with colleagues at MSFC has involved analysis of data obtained from the Thermal Electron Capped Hemisphere Spectrometer (TECHS) flown on the Sounding of the Cleft Ion =46ountain Energization Region (SCIFER) rocket is beginning to paint promising and tantalizing view of the thermal electron environment within the prenoon dayside ionospheric cusp during low solar activity. Calculated densities run from ~300 cm^{-3} to ~3000 cm^{-3} throughout the mission profile which attained an apogee of 1452km over the dayside cusp. Preliminary results indicate that TECHS successfully resolved, never-before observed, thermal electron drift velocities on the order of 10's to 100's of km/sec. Drifts of this magnitude imply an observed thermal electron contribution to geomagnetic field-aligned currents of ~10's of =B5A/m^2. Further analysis will focus on obtaining a preliminary value for a current threshold for the onset of current-driven instabilities. The accompanying electron distribution function plots illustrate the initial efforts to sensitively measure both moments such as density and even field-aligned velocity as well as significant features of these distribution functions.

Work is also under way for the construction of an improved version of TECHS to fly on the Cleft Accelerated Plasmas Experiment Rocket (CAPER) scheduled to revisit the dayside cusp/cleft region from the Andoya, Norway launch facility in January 1998. This work includes the development of an Ion-version of TECHS called the Thermal Ion Capped Hemisphere Spectrometer (TICHS) to be flown on the same mission.

Publications:

Craven, P. D., R. H. Comfort, and P. G. Richards, Thermal N+ in the inner magnetosphere, *EOS 77*, S230, 1996; presented to the Spring Meeting of the American Geophysical Union, Baltimore, May 20-24, 1996.

Craven, P. D., D. L. Gallagher, and R. H. Comfort, The relative concentration of He^+ in the inner magnetosphere as observed by DE1/RIMS, *J. Geophys. Res.*, in press, 1996.

Fok, M.-C., T. E. Moore, and M. E. Greenspan, Ring current development during storm main phase, *J. Geophys. Res.*, 101, 15,311-15,322, 1996.

Fok, M.-C., Ring current and associated effects, a chapter in the book: Trapped Radiation Belt Physics, China, in press, 1996.

Fok, M.-C., and T. E. Moore, Ring current modeling in a realistic magnetic field configuration, Geophys. Res. Lett., submitted, 1996.

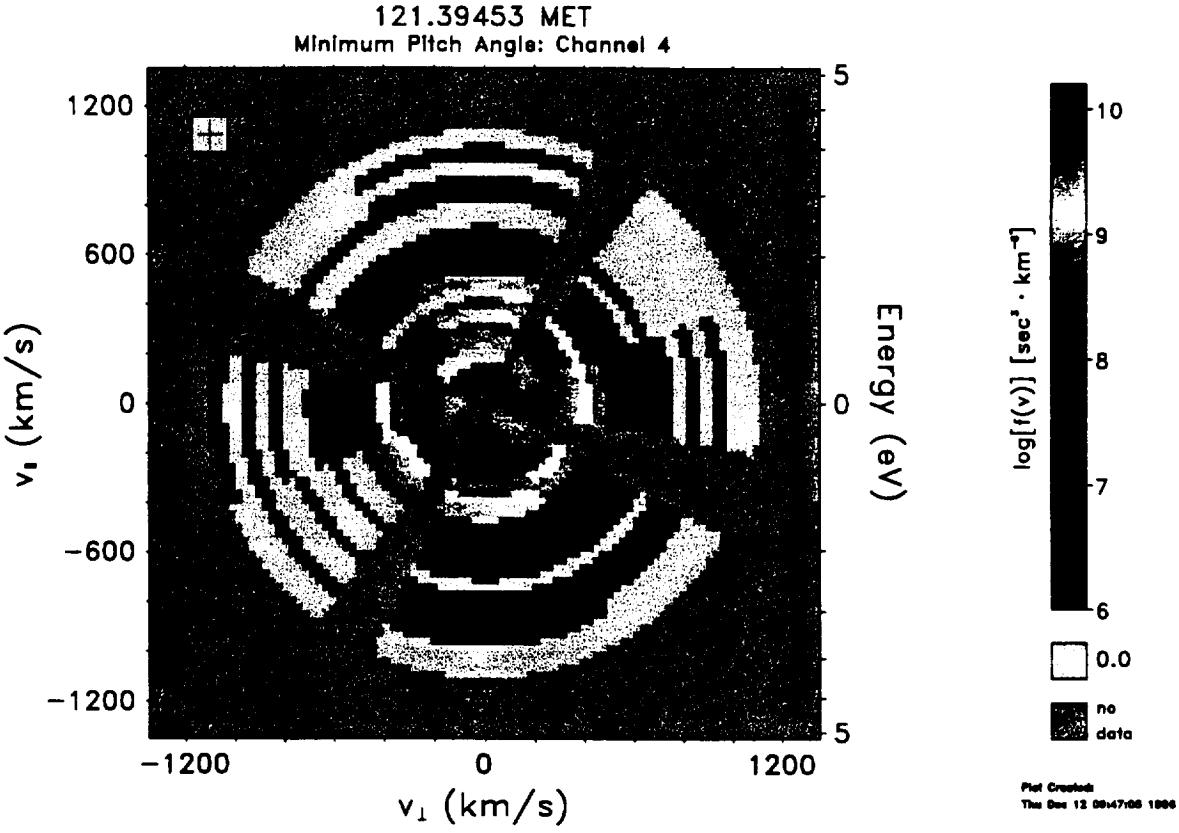
Gallagher, D. L., P. D. Craven, and R. H. Comfort, Global core plasma model, *EOS 77*, S229, 1996; presented to the Spring Meeting of the American Geophysical Union, Baltimore, May 20-24, 1996.

Horwitz, J. L., and T. E. Moore, "Four contemporary issues in ionospheric plasma supply to the magnetosphere", in preparation for submission to *Space Science Reviews* , 1996.

Khazanov, G. V., T. E. Moore, M. W. Liemohn, V. K. Jordanova, and M.-C. Fok, Global, collisional model of high-energy photoelectrons, *Geophys. Res. Lett.*, 23, 331-334, 1996.

SCIFER / TECHS

Instaneous Thermal Electron Phase Space Density Distribution
TECHS Frame of Reference : Sweep 7 : Skin Bias = + 1.0V
Andoya, Norway : 25 January 1995 : 06:24:48 UT



SCIFER Vehicle Parameters

Altitude = 278.814 km
$V_{s/c}$ = −0.27223800 V
GLAT = 70.1697° North
GLON = 15.9085° East

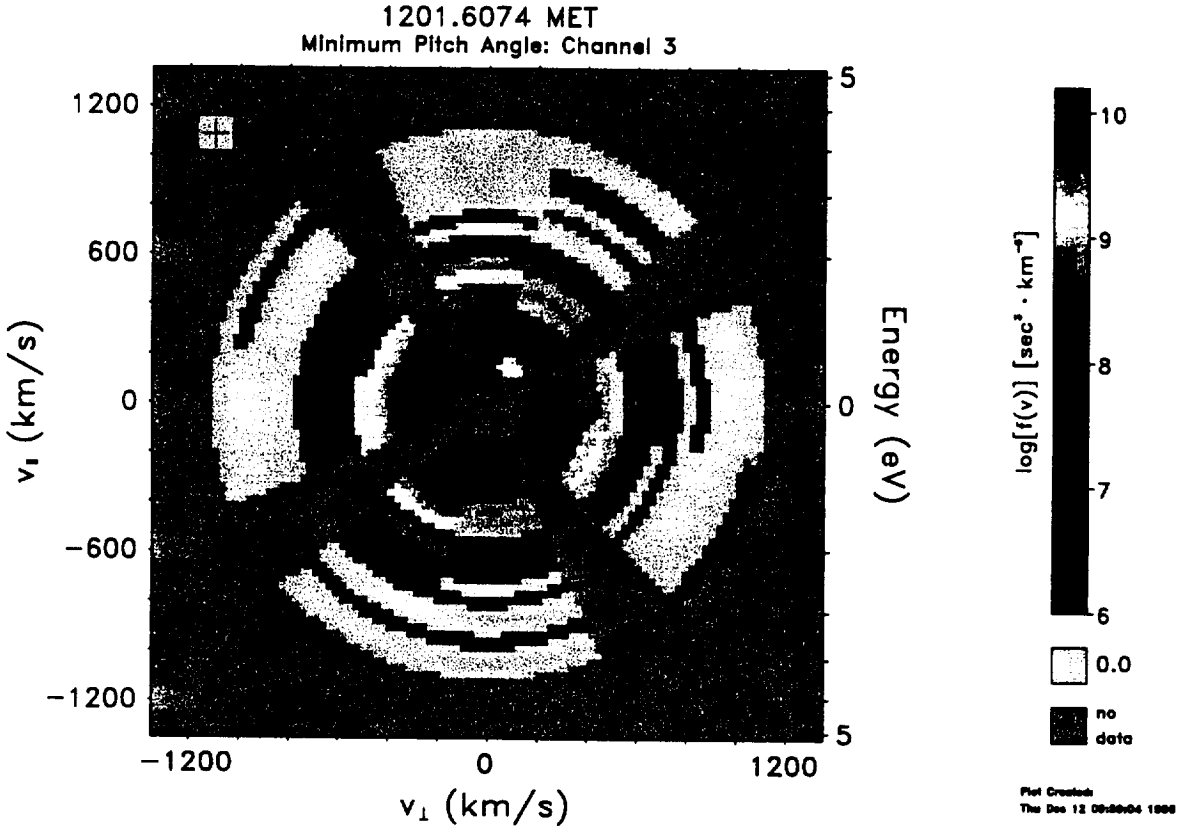
Thermal Electron Bulk Parameters

N_e = 658.32740 cm^{-3}

V_{para} = −17.329459 km/s
V_{perp} = 18.406665 km/s
T_{para} = 0.29613657 eV
T_{perp} = 0.26938914 eV

SCIFER / TECHS

Instaneous Thermal Electron Phase Space Density Distribution
TECHS Frame of Reference : Sweep 7 : Skin Bias = + 1.0V
Andoya, Norway : 25 January 1995 : 06:24:48 UT



SCIFER Vehicle Parameters

Altitude = 684.820 km
GLAT = 81.1001° North
$V_{s/c}$ = −0.32011700 V
GLON = 20.5923° East

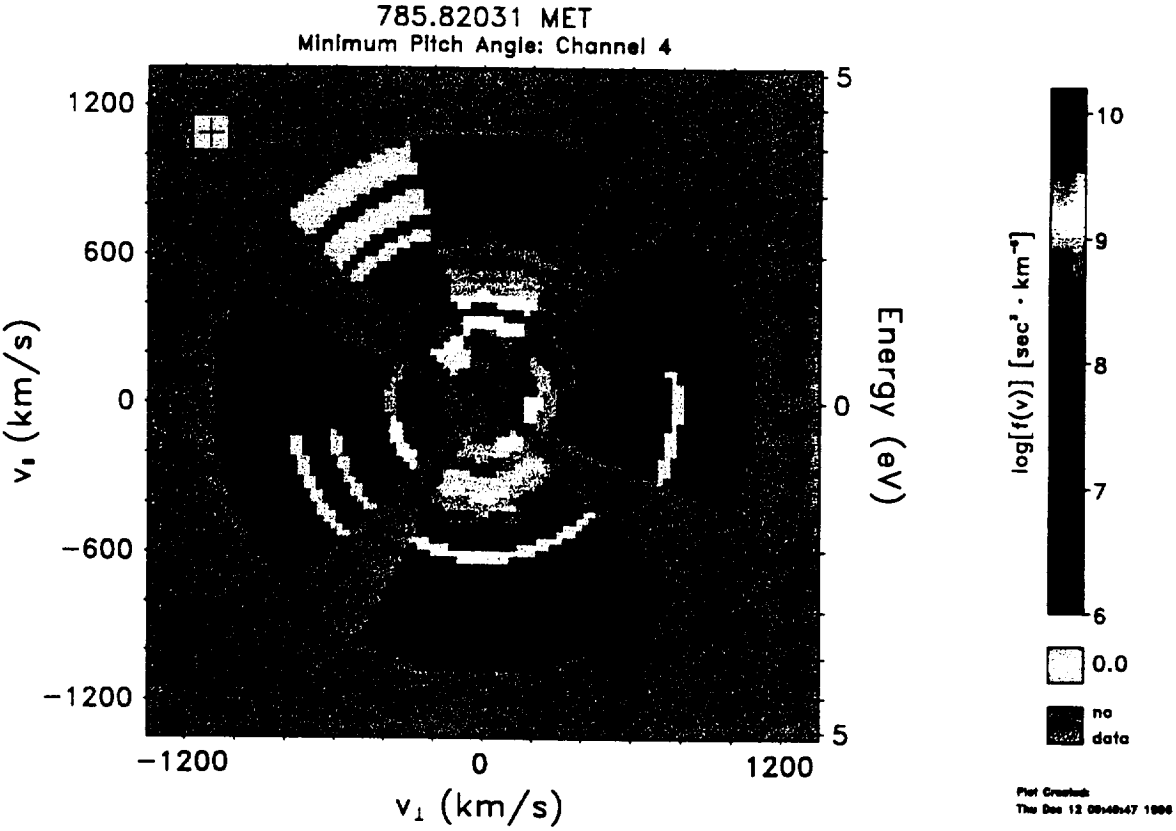
Thermal Electron Bulk Parameters

N_e = 1319.3478 cm^{-3}

V_{para} = 8.7407776 km/s
T_{para} = 0.29118467 eV
V_{perp} = −16.374580 km/s
T_{perp} = 0.31300647 eV

SCIFER / TECHS

Instaneous Thermal Electron Phase Space Density Distribution
TECHS Frame of Reference : Sweep 7 : Skin Bias = + 1.0V
Andoya, Norway : 25 January 1995 : 06:24:48 UT



SCIFER Vehicle Parameters

Altitude = 1437.38 km
GLAT = 76.9743° North
$V_{s/c}$ = −0.19229800 V
GLON = 17.0135° East

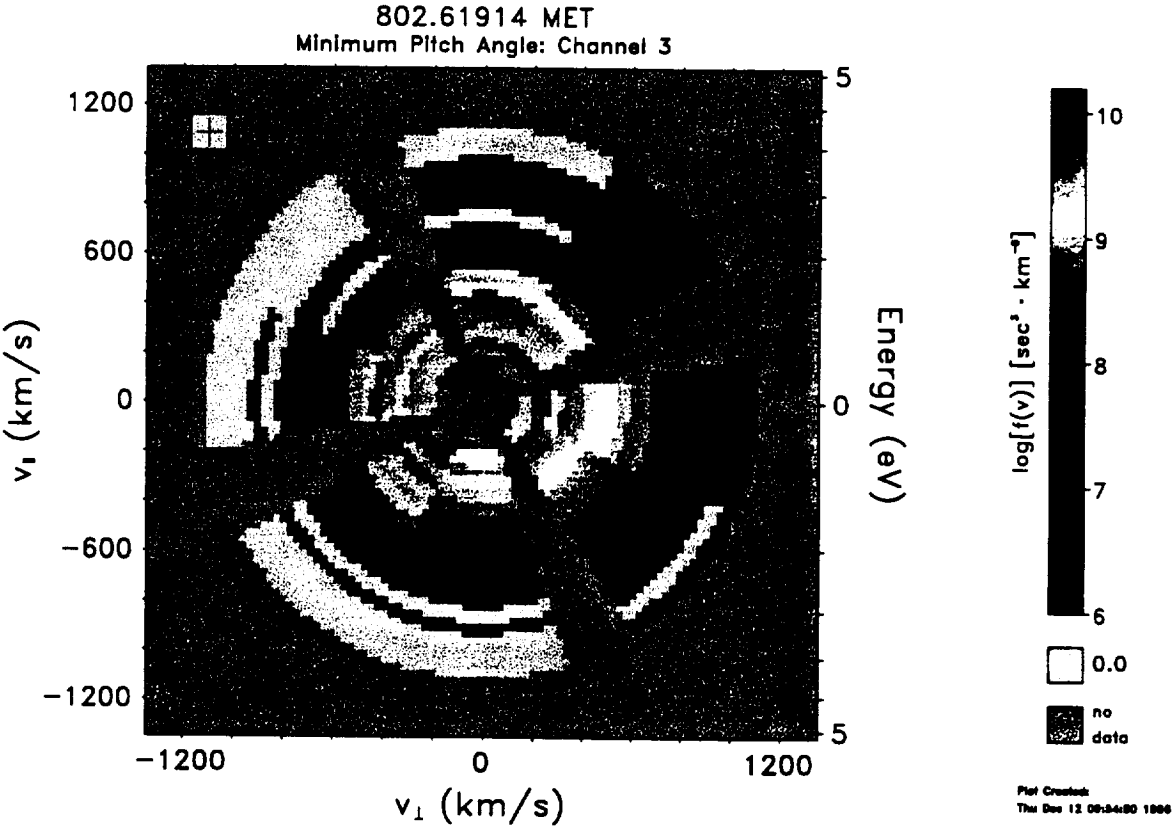
Thermal Electron Bulk Parameters

N_e = 360.69317 cm^{-3}

V_{para} = 124.90388 km/s
T_{para} = 0.81290848 eV
V_{perp} = 129.00689 km/s
T_{perp} = 0.64742448 eV

SCIFER / TECHS

Instaneous Thermal Electron Phase Space Density Distribution
TECHS Frame of Reference : Sweep 7 : Skin Bias = + 1.0V
Andoya, Norway : 25 January 1995 : 06:24:48 UT



SCIFER Vehicle Parameters

Altitude = 1429.09 km
$V_{s/c}$ = −0.32132300 V
GLAT = 77.1304° North
GLON = 17.0808° East

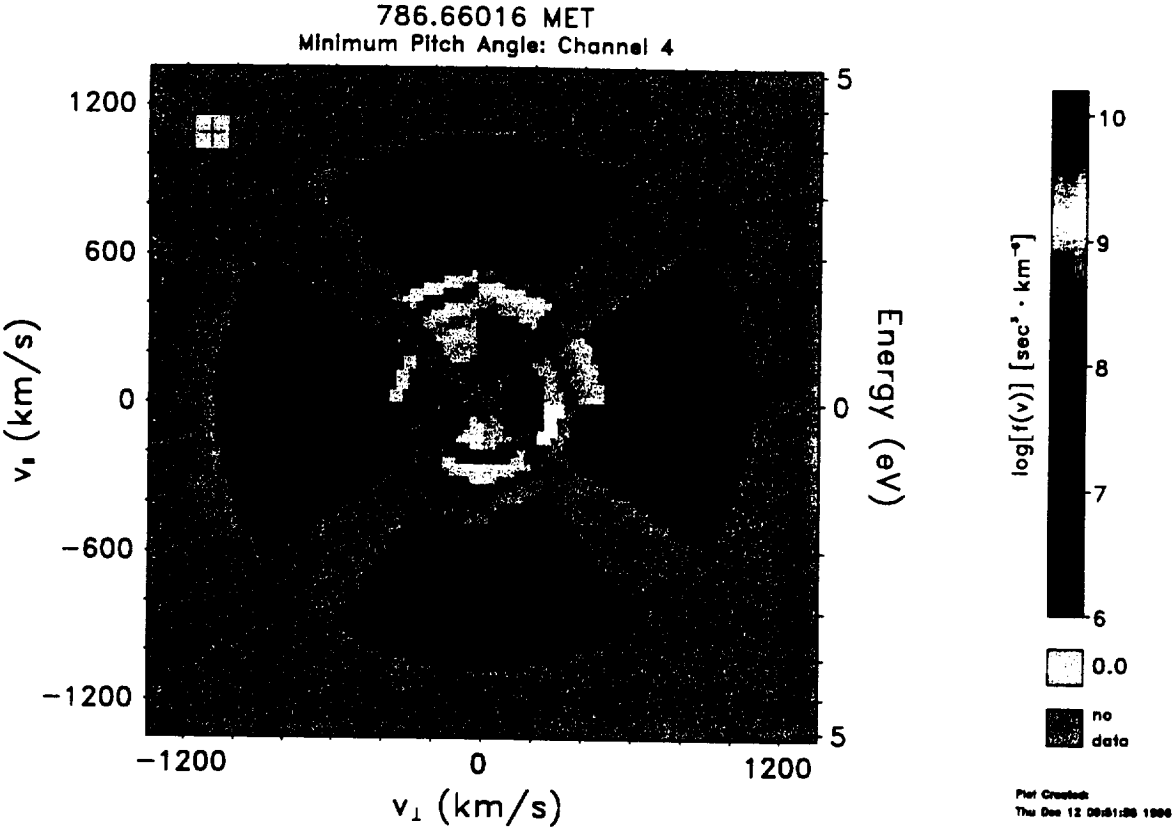
Thermal Electron Bulk Parameters

N_e = 750.94057 cm^{-3}

V_{para} = 109.91953 km/s
V_{perp} = −11.375490 km/s
T_{para} = 0.54202896 eV
T_{perp} = 0.56089049 eV

SCIFER / TECHS

Instaneous Thermal Electron Phase Space Density Distribution
TECHS Frame of Reference : Sweep 7 : Skin Bias = + 1.0V
Andoya, Norway : 25 January 1995 : 06:24:48 UT



SCIFER Vehicle Parameters

Altitude = 1437.05 km
GLAT = 76.9814° North
$V_{s/c}$ = −0.13307100 V
GLON = 17.0158° East

Thermal Electron Bulk Parameters

N_e = 372.94384 cm^{-3}

V_{para} = 84.411398 km/s
T_{para} = 0.96279480 eV
V_{perp} = 117.83125 km/s
T_{perp} = 0.69017822 eV

Kozyra, J. U., M.-C. Fok, E. R. Sanchez, D. S. Evans, D. C. Hamilton, and F. Nagy, The role of precipitation losses in producing the rapid early recovery phase of the great magnetic storm of February 1986, *J. Geophys. Res.*, submitted, 1996.

Moore, T.E., C.J. Pollock, M.L. Adrian, P.M. Kintner, R.L. Arnoldy, K.A. Lynch, and J.A. Holtet, The Cleft Ion Plasma Environment At Low Solar Activity, *J. Geophys. Res.*, 23, 1877, 1996.

Pollock, C.J., T.E. Moore, M.L. Adrian, P.M. Kintner, and R.L. Arnoldy, SCIFER - Cleft Region Thermal Electron Distribution Functions, *J. Geophys. Res.*, 23, 1881, 1996.

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Presentations:

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Fok, M.-C., J. D. Perez, R. W. Spiro, and T. E. Moore, Neutral Atom Imaging of a Documented Storm, AGU Fall Meeting, California, December 1996.

Gallagher, D. L., P. D. Craven, and R. H. Comfort, Global Core Plasma Model, Huntsville Workshop on Encounter Between Global Observations and Models in the ISTP Era, Guntersville State Park, Guntersville, AL September 15-20, 1996.

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Hirahara, M., T. Mukai, and E. Sagawa, Energy-dispersed signatures of ionospheric ions in the central plasma sheet, Chapman Conference in Kanazawa Japan (invited talk)

Hirahara, M, K. Seki, T. Terasawa, T. Mukai, M. Hoshino,Y. Saito, T. Yamamoto, and S. Kokubun, Multiple ion flows in the lobe/mantle, the PSBL, and the magnetopause, The Yosemite 1997 meeting (poster)

Horwitz, J. L., and T. E. Moore, "Contemporary issues in ionospheric plasma supply to the magnetosphere", invited presentation at the International Space Science Institute Workshop in Bern, Switzerland, October, 1996.

Horwitz, J. L., Core plasma dynamics in the inner magnetosphere: What we (think we) know and what we might learn in 5 years , invited tutorial presented to the GEM Workshop, June 1996.

Horwitz, J. L., M. Hirahara, T. E. Moore, M. O. Chandler, C. R. Chappell, C. J. Pollock, J. F. Spann, J. L. Burch, J. H. Waite, Jr., D. T. Young, D. J. McComas, J. E. Nordholt, J. J. Berthelier, High and low-altitude views of the polar cusp in low-energy ions: Initial results from the TIDE/PSI suite on POLAR, invited presentation for the GEM Workshop, June, 1996.

Title and authors: TBD, (On Upflowing ionospheric ions, auroral forms, and wave activities observed by the POLAR satellite during an active time)

The USRA Activity Report SUB96-077 includes USRA Space Plasma Physics specific activities (see Appendix I).

7. Pre-College Educational Outreach Program

No funds were allocated for pre-college educational outreach program during this period of performance.

Appendix I

INTERIM ACTIVITIES REPORT
Year Two, 15 February 1996 - 14 February 1997

Submitted To

The University of Alabama in Huntsville

BY

Universities Space Research Association
The American City Building, Suite 212
Columbia, MD 21044

In Fulfillment of Paragraph 1260.402(d)(2) of NASA Handbook 5800.1C

Subcontract SUB96-077
Cooperative Agreement NCC8-65

for The Institute of Space Physics, Astrophysics and Education (ISPAE)*
(*Jointly Operated by the University of Alabama in Huntsville and The Universities Space Research Association)

December 10, 1996

ACTIVITY REPORT

YEAR TWO
COOPERATIVE AGREEMENT NCC8-65
SUBCONTRACT SUB96-077

Institute for Space Physics, Astrophysics and Education (ISPAE)

Universities Space Research Association performed research under the purview of the Institute for Space Physics, Astrophysics and Education (ISPAE) in three scientific areas during the second year of Cooperative Agreement NCC8-65. These general areas of research included: Gamma-Ray Astronomy, X-Ray Astronomy, and Space Physics. Dr. Chryssa Kouveliotou served as the Deputy Director of the ISPAE and Ms. Paula Cushman functioned as USRA's Associate Director for Administration. Subcontract SUB96-077 was awarded to USRA in the amount of $1,740,332 for the period February 15, 1996 through February 14, 1997.

In addition to the 16 full time equivalents working on ISPAE for USRA, there was one subcontract issued to Teledyne Brown Engineering for Dr. William Henze.

Scientists, research associates, and mission operations and data analysis personnel on Subcontract SUB96-077 included the following:

Gamma-Ray Astronomy:

Ms. Susan Aldridge, BATSE System Manager, maintained all hardware and software for the BATSE computing network. Performed system restorations and operating system updates on platforms utilizing the Solaris and Open VMS operating systems.

Ms. Susan Benefield, ISPAE Logistics Coordinator, resigned from USRA in November 1996 to relocate. During year two Ms. Benefield was responsible for arranging seminar logistics and for compiling the data base related to Gamma-Ray conferences and the work related to the 1995 Huntsville Gamma-Ray Symposium.

Ms. Katherine Hagedon, Mission Operations and Data Analysis Specialist, resigned from USRA in August 1996 to pursue an advanced degree at an Ohio university. She processed burst triggers to determine the type of event and direction of origin during year two. She operated the software to calculate the V/Vmax statistic for bursts and to spot and correct errors in that calculation.

Dr. Thomas Koshut, Staff Scientist, joined USRA this year as a post-doc working on bursting pulsars. He performed research related to cyclotron lives in the data. His research involves ensuring the detectors are set to get most out of the low energy data.

Dr. Chryssa Kouveliotou, Deputy Director of ISPAE and Sr. BATSE Scientist, has produced over 100 publications and ten proposals as a Principal Investigator during the year. Her main scientific results have been in the area of Soft Gamma Repeaters (SGRs). She works on temporal structure analyses and on transient discrete sources.

Dr. Michael McCollough, Staff Scientist, moved to USRA after being on a subcontract with Hughes STX for ISPAE. His research is in the area of supernova remnant survey and hard X-Ray/Radio Correlation studies of Cygnus X-3 and SS433. The research has look at the sensitivity to which BATSE occultation data can be used and at the detection of relativistic jets.

Mr. Burl Peterson, Mission Operations and Data Analysis Specialist, performs daily data processing and fine tunes programs using plots detectors. He performs programming tasks and makes coding changes as needed.

Dr. Craig Robinson , Staff Scientist, works primarily as part of the Earth Occultation Team of BATSE. He has lead ground-based observations and RZTE observations for the multiwavelength campaign on the Galactic superluminal source GRO J1655-40. With the data analysis underway, publications will follow that will serve as an important concentration of CGRO information and will afford many scientists the opportunity to include numerous scientists at various wavelengths in studies performed with CGRO.

Ms. Maitrayee Sahi, Mission Operations and Data Analyst Specialist, provided scientific analysis and support to Occultation and Pulsar groups. She pursued research on the Occultation Data Delivery projects for the Gamma Ray Observatory Science Support Center. She completed quality flags for the initial period of the BATSE BURSTER and completed location processing for the triggers.

Dr. Matthew Scott, Staff Scientist, focused on GRO J1750-27 and Crab Pulsar research. His research resulted in the discovery that the timing noise is 1/f^3 in pulse phase, not 1/f^4 as previously thought (implying a blue noise torque process acting on the neutron star crust rather than a white noise process acting on the neutron start crust rather than a white noise process.

Dr., Shuang-Nan Zhang, Staff Scientist, pursued research in Earth occultation monitoring of the hard X-ray sky, analysis and publication of BATSE data and the coordination of multiwavelength observations. X-Ray burster emphasis was done to determine the system parameters.

X-Ray Astronomy:

Dr. Robert Austin, Staff Scientist, was responsible for characterization and verification of the AXAF x-ray source system, instrument scientist for AXAF. He developed detectors for balloon-based X-Ray astronomy.

Dr. Jeff Kolodziejczak - Staff Scientist, works as an AXAF Calibration Scientist performing research in optics and detectors for X-Ray and gamma-ray astronomy.

Mr. Takahisha Minamitani - Research Associate, is working to complete his Ph. D. and is working in detector development for the AXAF. He was responsible for maintaining the instrument calibration and balance for balloon tests while on extended dislocation in New Mexico in September and October.

Dr. Douglas Swartz, Staff Scientist, worked on the AXAF Calibration Task Team and assisted with project science computer hardware maintenance and support. He developed and documented X-Ray Source System software for data visualization and analysis as well as the development and application of computer simulations of proportional counter X-Ray detectors. He was responsible for scientific research in supernova spectral modeling, radiative transfer and X-Ray sources.

Dr. Galen Zirntein, Staff Scientist, was involved in characterization and calibration of X-Ray source systems at the MSFC X-Ray Calibration Facility in preparation for calibration of the AXAF HRMA.

Space Physics:

Dr. Mei Ching Fok - Staff Scientist works on global ring modeling and ring current-plasmasphere coupling. Has had an experiment selected (MIDEX) to fly in ~ 2002.

USRA Proposals:

Scientists in ISPAE submitted over twenty proposals in response to NRA's and AO's during this reporting period. The proposals included:

XTE Cycle 2 Guest Observer Program
Cycle 6 CGRO
National Space Weather Program AO
SAX AO1
NRA 96-ROSAT-07

USRA Publications:

The list of publications for the 1996 calendar year is being compiled at the time of this report, but the total number of publications submitted and appeared exceeds 100.

Consultants and Visiting Collaborators:

USRA provided assistance to various collaborators during year two to enable them to participate in the research at the Space Sciences Laboratory or to work elsewhere and present their findings in report form for ISPAE. A summary follows.

Dr. Tony Armstrong of SAIC worked with the X-Ray Astronomy group to perform modifications to the specialized SAIC Monte Carlo radiation transport code system for application to background simulations of the IBIS detector including the interfacing of the GEANT 3-D mass model of the INTEGRAL spacecraft and detector systems and the developing interfacing of radiation environment source routines for diffuse cosmic gamma-rays and galactic cosmic ray protons.

Dr. Tomek Bulik — December, BATSE Colloquium Series
Nicolaus Copernicus Astronomical Center, Poland

Dr. John Cannizzo — May, BATSE Colloquium Series, "On the Nature of the Giant Outbursts in
LHEA, NASA/GSFC — Bursting Pulsar GRO J1744-18"

Dr. Phil Hardee — February, BATSE Colloquium Series, "Emission and Dynamics of
Univ. of Alabama — Relativistic Jets in Galactic Microquasars"

Dr. Bob Hjellming — February, BATSE Colloquium Series, "Relativistic Jet Sources in Our
NRAO, New Mexico — Galaxy"

Dr. Jeff McClintock — April, BATSE Colloquium Series, "Black Hole X-Ray Novae"
Harvard-Smithsonian

Dr. Ron Remillard — May, BATSE Colloquium Series, "XTE/ASM Communications"
MIT

Dr. Roger Romani — March, BATSE Colloquium Series, "Gamma Ray Pulsars"
Stanford University

Dr. Chunming Wang, University of Southern California, performed research related to the development of a direct all-sky imaging algorithm. The method of investigating a direct all-sky imaging algorithm focused on validation of a series of numerical experiments on an implementation of the algorithm using simulated data. The conclusions lead to the development of procedures to

access data in FITS Files containing BATSE data in order to work within the storage limit on a given system.

Dr. Kinwah Wu Univ. of Sydney	February, BATSE Colloquium Series, "Optical and Radio Observation of the Black Hole Transient GRO J1655-40"

Dr. Wenfei Yu of the High Energy Astrophysics laboratory at the Institute of High Energy Physics, Beijing China, served as a visiting graduate researcher during this period to complete his doctoral work and to collaborate on research related to the Gamma-Ray astronomy work of the BATSE group.